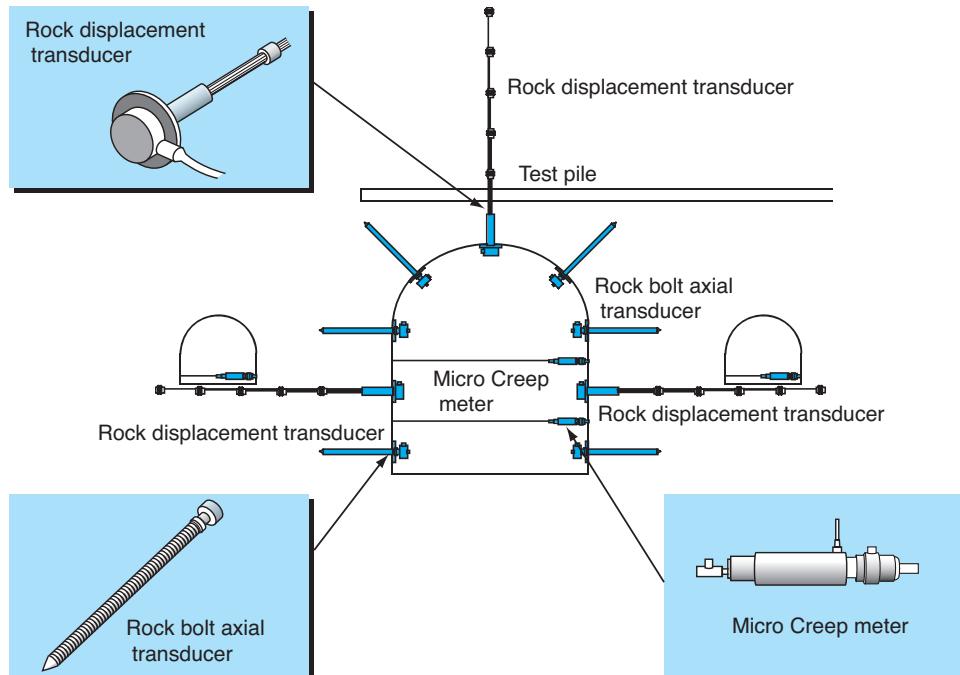


9 Underground Opening Measurement

As the cross section of an underground opening becomes large, ground stability decreases and a large-scale support structure is required. The stability of an opening depends on surrounding ground. Since it is very difficult to clarify the level of ground stability by conducting surveys, data on the behavior of ground gathered during construction is analyzed and analysis results are reflected to design and construction. This is an observational construction control system that our company proposes to customers.



A list of Measuring Instruments

Measurement items	Instruments	Type	Description
Displacement of surrounding bedrock (Underground displacement)	Rock displacement transducer	KLB-A	An anchor is fixed in the bore hole, and change of displacement between the anchor and bedrock surface is measured.
Convergence and subsidence of top part	Micro creep meter	KH-A	Measurement pin is fixed on bedrock or concrete surface
	Survey apparatus	Other maker	Measures distance between the pins.
	Electronic distance meter	Other maker	A target is fixed to bedrock or concrete surface to measure an absolute displacement from the reference point.
Load on PS concrete structures	Center-hole type load cell	KCM-NA, KCE-NA	Load cell is installed at the foot of PS structure to measure change of tensile force.
	Rock-bolt axial force meter	KRA-A	Measures rock-bolt axial force.
Stress of arch concrete structures	Reinforcing bar meter	KSA-A, KSAT-A	
	Strain transducer	KM-A, KM-AT, KM-B, KM-BT	Installed to arch concrete structures to confirm design strength and time-dependent change of stress and stress distribution.
	Thermocouple	KT-A, T	
Non-stress casing	KM-B, KM-BT, KMF		
The amount of spring	Triangular weir water meter	Made to order	

Measuring System Block Diagram

